NDACC:

Network for the Detection of Atmospheric Composition Change

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What is NDACC?

Formerly known as "NDSC"

1. International network of 70+ high-quality, remote-sensing research stations
2. Observe and understand the physical and chemical state of the stratosphere and upper troposphere
3. Assess the impact of stratosphere changes on the underlying troposphere and on global climate
4. Detect trends in overall atmospheric composition and understand their impacts on the stratosphere and troposphere
5. Establish links between climate change and atmospheric composition

What is NDACC?

Steering Committee

- Co-Chair
- Co-Chair
- Executive Secretary
- Working Group Representatives
- Peer, Ex Officio, Emeritus, and Cooperating Network Representatives

Working Groups and Theme Groups

Dobson & Brewer | FTIR | LIDAR | Microwave | Sondes | Spectral UV | UV-Visible

Satellite | Theory & Analysis | Water Vapour | Ozone | Measurement Strategies & Emphases

Quality Assurance

Protocols

Data
Measurements
Instrument Validation and Intercomparisons
Theory and Analysis

Goals & Results

Long-term time series for detecting andunderstanding changes and trends in atmospheric composition and parameters

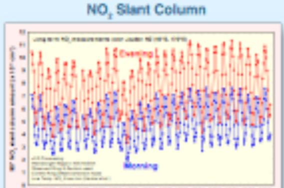
Establish scientific links and feedbacks between climate change and atmospheric composition

Satellite calibration, validation and gap-filling

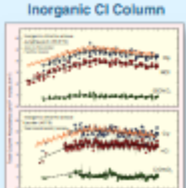
Collaborative support to scientific field campaigns and other chemistry and climate observing networks

Model validation and development support

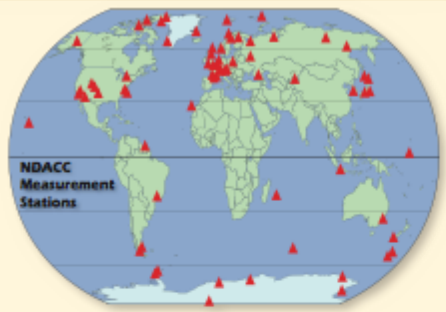
NO_2 Slant Column



Inorganic Cl Column



Station Network



Cooperating Networks

ESRL/GMD/HATS
TCCON
BSRN
AERONET
MPLNET
GRUAN
SHADOZ
AGAGE

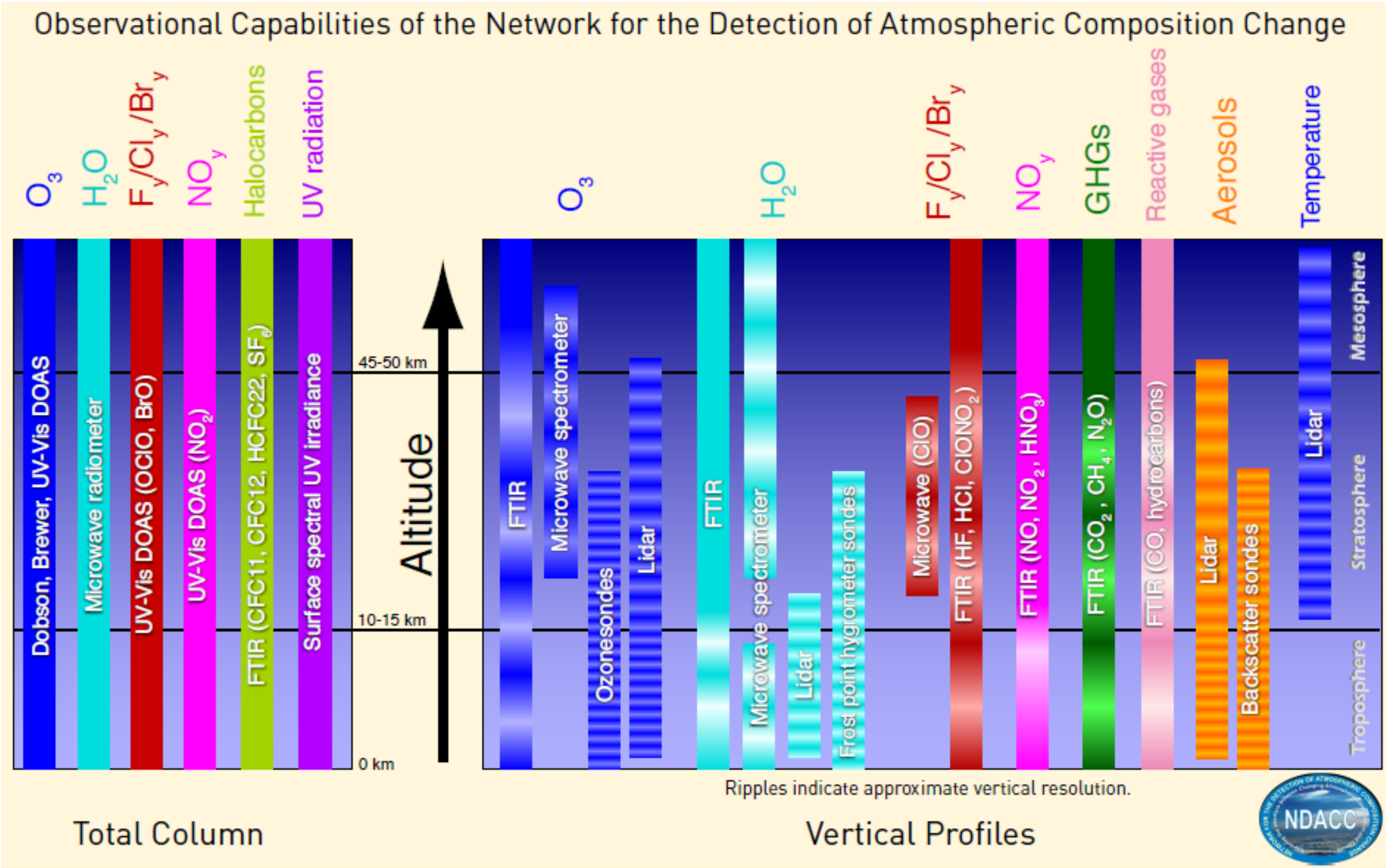
Outreach and Data Archiving

Data Host Facility

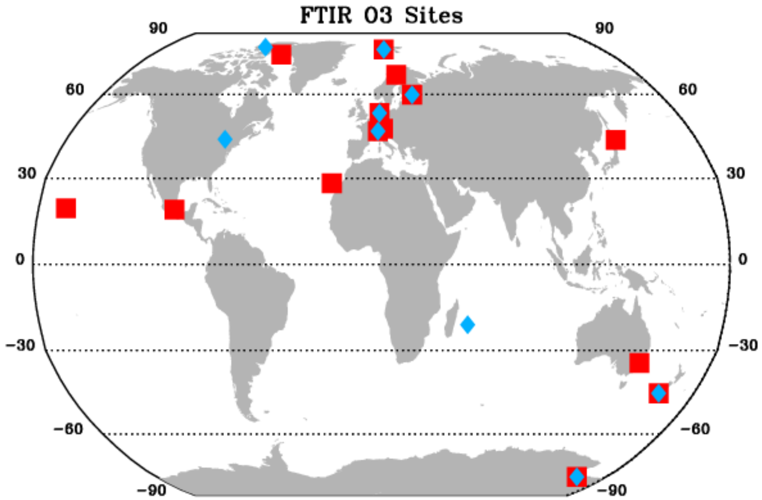
Web Sites

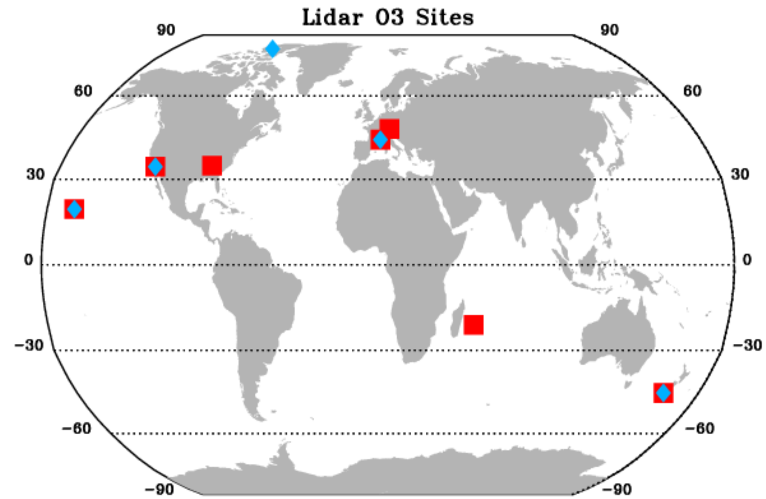
Newsletter
Brochure
Leaflet

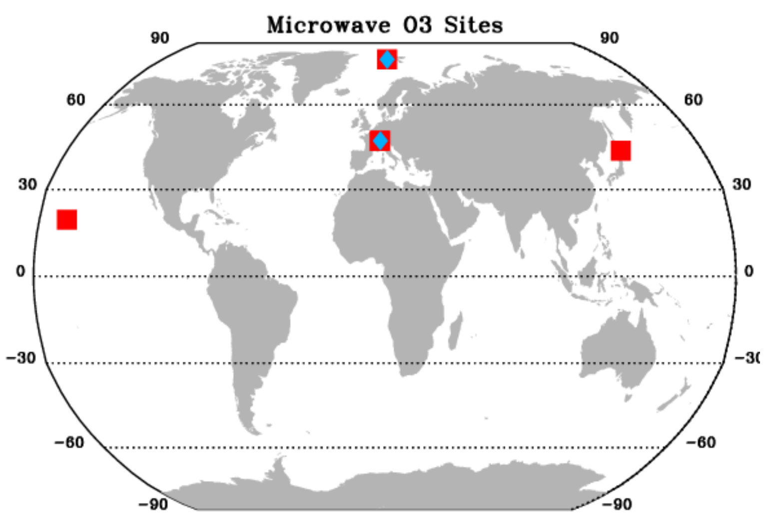
NDACC Measuring Capabilities

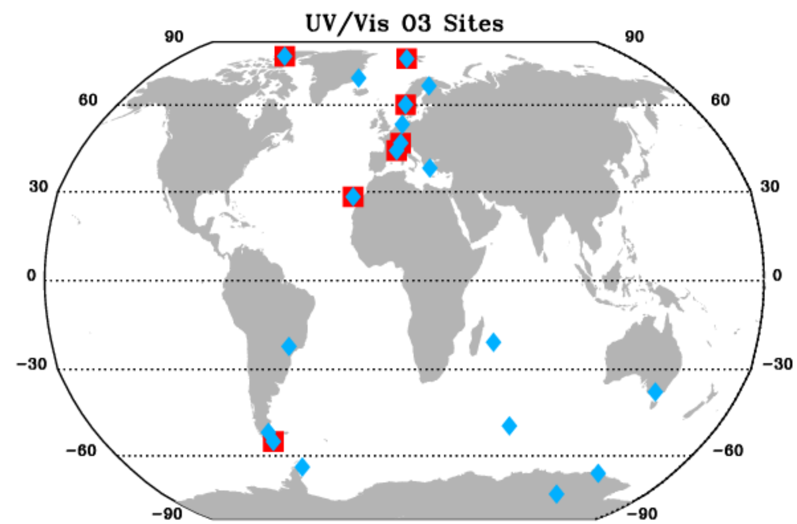


NDACC O3 Measuring Capabilities

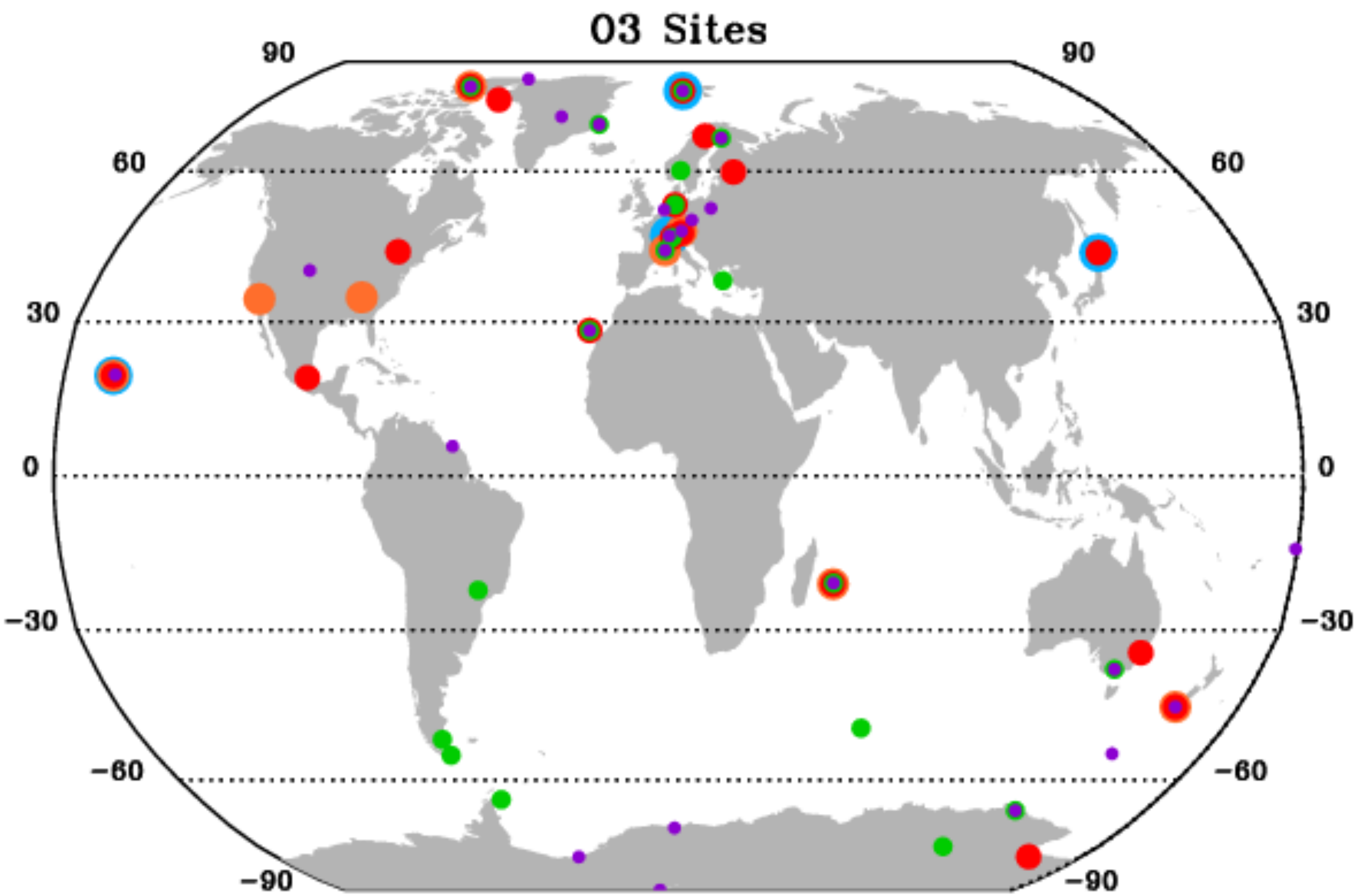






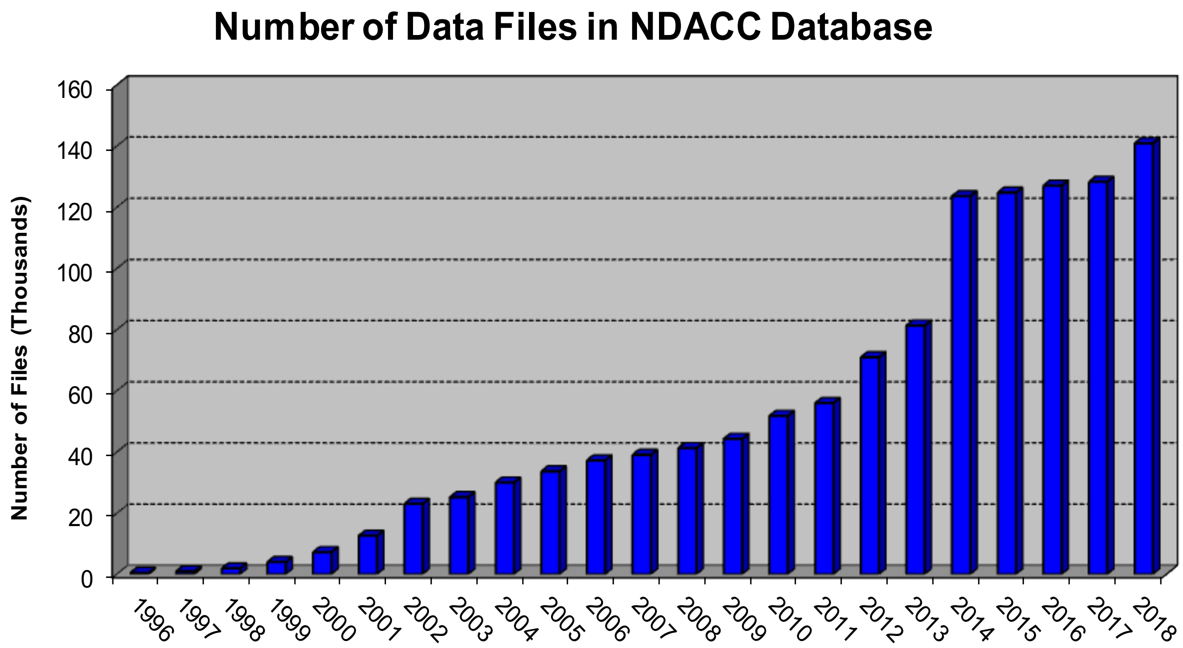


NDACC O3 Measuring Capabilities



Fun Facts About NDACC

1. Conceived initially in the 1980's by NASA, NOAA and CMA (Chemical Manufacturers Association)
2. Oldest data record in the NDACC archive: Sept, 1966: Boulder Dobson #09
3. Currently > 140,000 files in the NDACC data archive
4. Over 1 million file downloads so far in 2018
5. Files may be in NASA Ames or GEOMS HDF



New NDACC Website: www.ndacc.org

Network for the Detection of Atmospheric Composition Change

NDACC | STATIONS | INSTRUMENTS | DATA | ABOUT NDACC

Measurement Stations

Select a station on the map or in the list to access its public data.

Filter by:

HEMISPHERE
- ☐ Northern Hemisphere
- ☐ Southern Hemisphere

LATITUDINAL BAND
- ☐ Subtropics and Tropics
- ☐ Mid Latitude
- ☐ High Latitude

STATUS
- ☐ Active
- ☐ Inactive
- ☐ Campaign

INSTRUMENT
- ☐ Brewer
- ☐ Dobson
- ☐ FTIR Spectrometer
- ☐ Lidar
- ☐ Microwave Radiometer
- ☐ Sonde
- ☐ UV Spectroradiometer
- ☐ UV/Visible Spectrometer

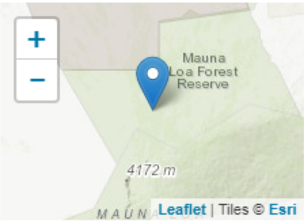
Clear all

Note: Anything that starts with www.ndsc.ncep.noaa.gov is the old site.
The old site was maintained until summer 2018, but is now out of date.

Example of an “NDACC Station page”

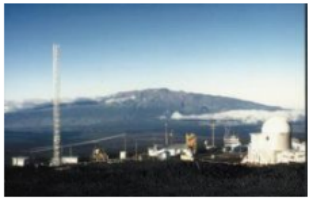
Mauna Loa, HI, United States

Latitude: 19.54° N
Longitude: 155.58° W
Elevation: 3397 m asl



Status: Active

Website(s):
Station Page
GMD Dobsons
NRL Water Vapor Microwave Instrument Group



Station Representative(s):
Dr. Russell C. Schnell
Global Monitoring Division
NOAA Earth System Research Laboratory
Colorado, USA

NDACC Measurements at the Mauna Loa, HI, United States Station

Instrument	Period	Parameter	Cooperating Institutions	Comments	Data link	Metadata link
Dobson D076	1963–present	Ozone	NOAA/ESRL, USA	20 retrievals per month	Ames	Metadata Summary
FTIR Spectrometer Bruker 125HR	1995–present	Column - multiple species, Profile - multiple species	NCAR, USA		Ames HDF	Metadata Summary
FTIR Spectrometer Bomem DA3	1991–1995	Column - multiple species	U. Denver, USA		Ames	Summary

Network for the Detection of
Atmospheric Composition Change

NDACC STATIONS INSTRUMENT

Home / Data / Data Use Agreement

Data Use Agreement

Whenever NDACC data is used in a publication the authors agree to acknowledge both the NDACC data center and the data provider as follows:

> "The data used in this publication were obtained from *institute or PI name* as part of the Network for the Detection of Atmospheric Composition Change (NDACC) and are publicly available (see http://www.ndacc.org)."

If substantial use is made of NDACC data in a publication an offer of co-authorship will be made through personal contact with the data providers or owners.

Users of NDACC data are expected to consult the online documentation and reference articles to fully understand the scope and limitations of the instruments and resulting data and are encouraged to contact the appropriate NDACC PI (listed in the data documentation on the web page) to ensure the proper use of specific data sets.

Data Citation requirements:
Public data (supported by taxpayers in many cases) BUT:

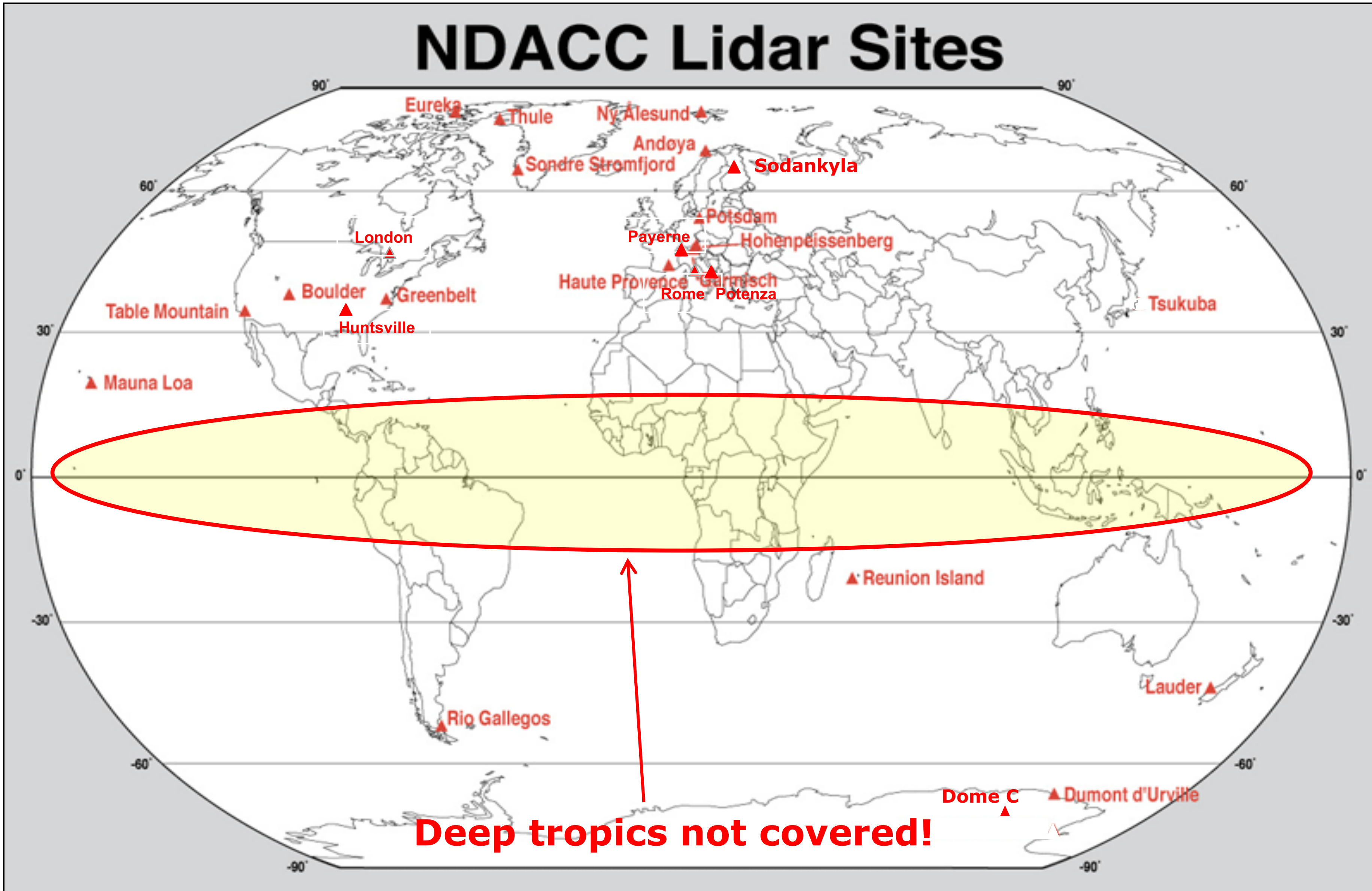
- Science is best supported if data users and originators work together
- Continued funding is best supported if proper acknowledgement is given. For many PIs # publications count.

NDACC Lidar Capabilities

What species?

➔ *1- Ozone DIAL (stratosphere):*	*12-50 km*	*Prec. 0-20%*	*Accur. 4%*
➔ *2- Ozone DIAL (troposphere):*	*0-20 km*	*Prec. 0-20%*	*Accur. 4%*
➔ *3- Temperature Rayleigh:*	*20-90 km*	*Prec. 0-10 K*	*Accur. 0.5 K*
➔ *4- Temperature vib.-Raman:*	*8-40 km*	*Prec. 0-10 K*	*Accur. 0.5 K*
➔ *5- Water vapor vib.-Raman:*	*0-20 km*	*Prec. 0-20%*	*Accur. 6%*
➔ *6- Stratospheric Aerosols*	*10-50 km*	*Prec. 0-20%*	*Accur. varies*

NDACC Lidars: (Almost) Global Network



Typical NDACC Stratospheric Ozone DIAL

Emitter:

- *1 Excimer laser: 308 nm, 60 W, 200 Hz rep. rate*
- *1 Nd:YAG laser: 355 nm, 5 W, 50 Hz rep. rate*
- *Mirrors, beam expanders, motion controller for beam alignment*

Receiver:

- *1 large telescope (91 cm diam.) for high-intensity Rayleigh (25-50 km) and Raman channels (10-35 km)*
- *2 small telescopes (10 cm diam.) for low-intensity Rayleigh channels (10-35 km)*
- *Mechanical chopper, dichroic beam splitters and interference filters for spectral separation*
- *Fast transient recorders for high sampling rate (e.g., 40 ns for 15 m sampling resolution)*

Strengths:

- *Mature technique (30+ years)*
- *DIAL technique does not require calibration*

Caveats:

- *3% accuracy limited by uncertainty in the ozone absorption cross-sections*
- *Requires expensive excimer laser*
- *Daytime measurements not possible with standard equipment*

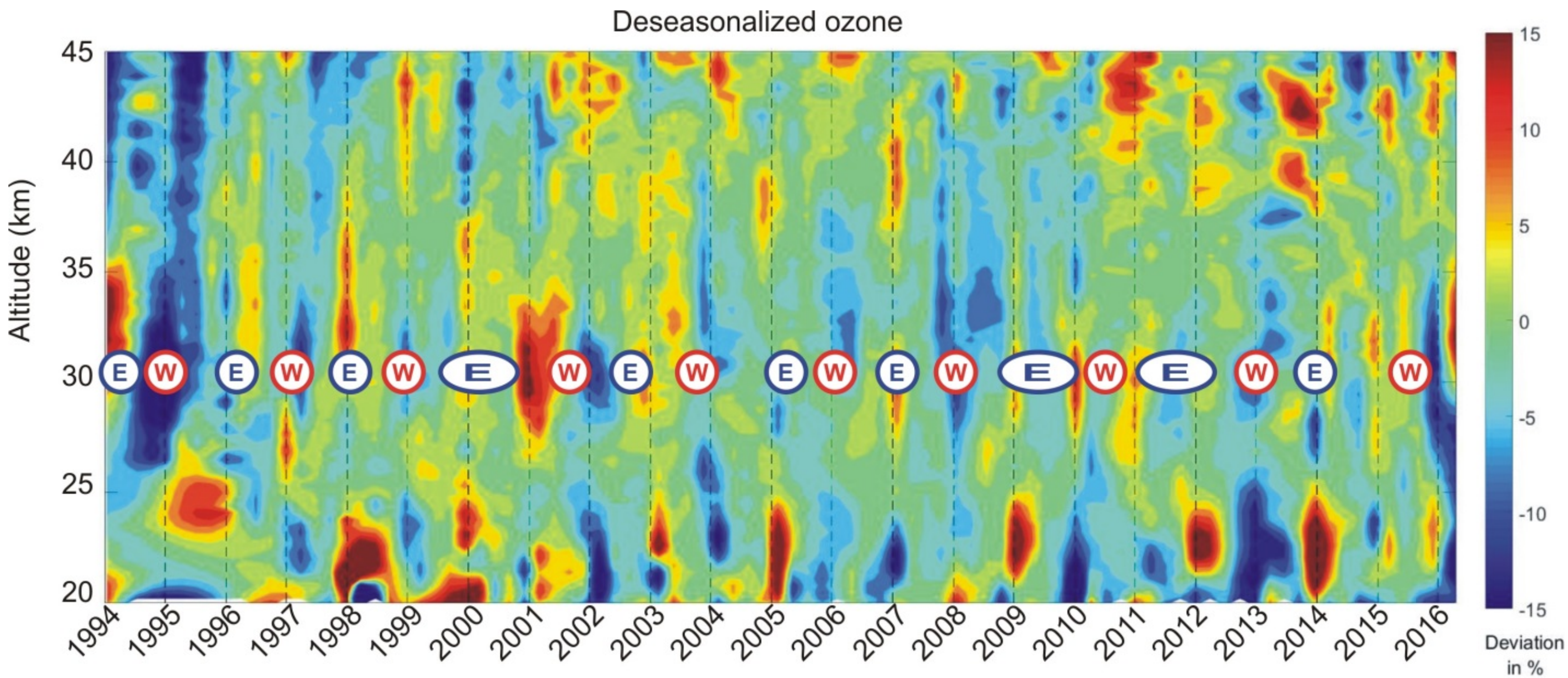
Applications:

- *satellite validation*
- *long-term monitoring (ozone depletion and recovery)*
- *process studies (ozone chemistry, stratosphere-troposphere exchanges)*

Ozone Monitoring with NDACC Lidars

The Quasi-Biennial Oscillation (QBO):

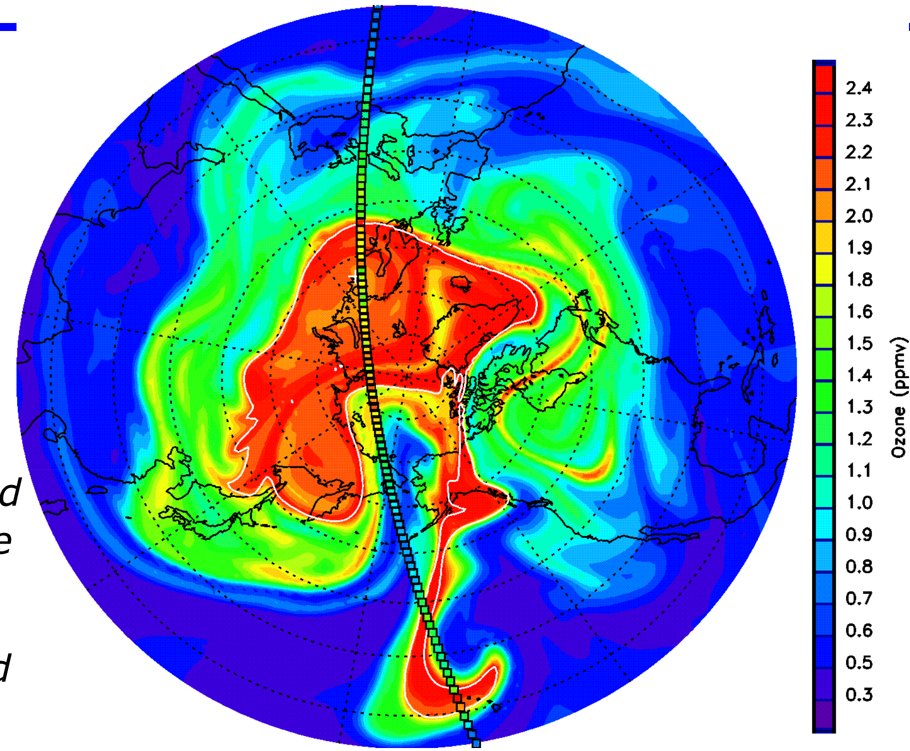
- *QBO = 10 to 27 months alternation of Westerly and Easterly winds in the tropics*
- *Due the changing vertical propagation of waves (mainly Kelvin and Gravity)*
- *Impacts stratospheric circulation, in particular the Brewer-Dobson Circulation*
- *The modulation of this circulation transports more/less ozone from the tropics to the poles, which appears on the lidar time-series as variations of up to +/-15%*



(Adapted from Leblanc et al., 2001)

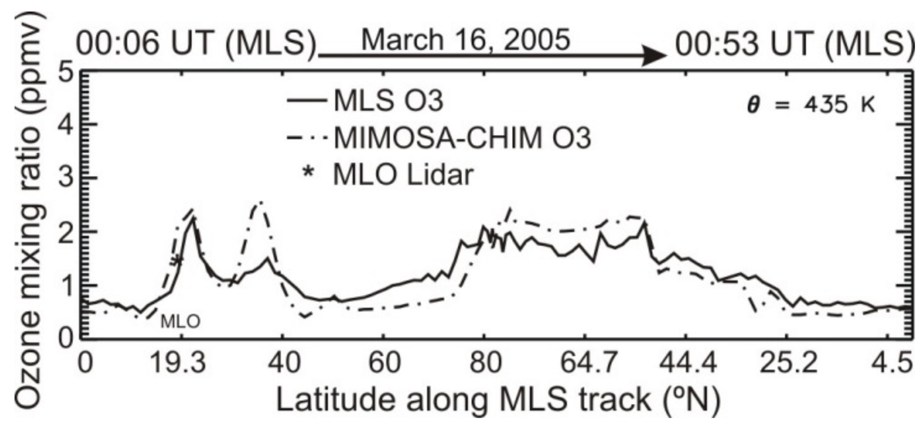
At MLO, ozone positive anomalies typically correlate with the Easterly phase of the QBO

Stratospheric Ozone Process studies



Springtime polar ozone transported to the tropics (March 2005):

- *When not depleted, springtime ozone maximizes inside the polar vortex (red)*
- *2D color contour map shows ozone modeled by chemical transport model MIMOSA in the lower stratosphere (435 K, approx. 18 km)*
- *Aura-MLS measurements are superimposed (small colored squares crossing over)*
- *Map shows vortex stretching to the subtropics on March 17, bringing high ozone above MLO, Hawaii on that day*
- *High ozone (>1.5 ppmv) is simultaneously observed by MLO lidar (star) and by Aura-MLS, and matches well modeled ozone*



(Leblanc et al., 2006)

Typical NDACC Tropospheric Ozone DIAL

Emitter:

- *Shorter wavelengths than stratospheric DIAL (less absorption in the troposphere)*
- *1 "quadrupled" Nd:YAG laser: 2 beams at 266 nm, 1.2 W, 30 Hz rep. rate*
- *2 Raman cells to shift 266 nm to 289 nm and 299 nm respectively*
- *Mirrors, beam expanders, motion controller for beam alignment*

Receiver:

- *1 large telescope (90 cm diam.) for high-intensity (9-20 km)*
- *4 small telescopes (5-10 cm diam.) for low-intensity channels (3-12 km)*
- *Dichroic beam splitters and interference filters for spectral separation*
- *Fast transient recorders for high sampling rate (e.g., 20 ns for 7.5 m sampling resolution)*

Strengths:

- *Mature technique (20+ years)*
- *DIAL technique does not require calibration*
- *Daytime measurements possible with standard equipment*

Caveats:

- *3% accuracy limited by uncertainty in the ozone absorption cross-sections values*

Applications:

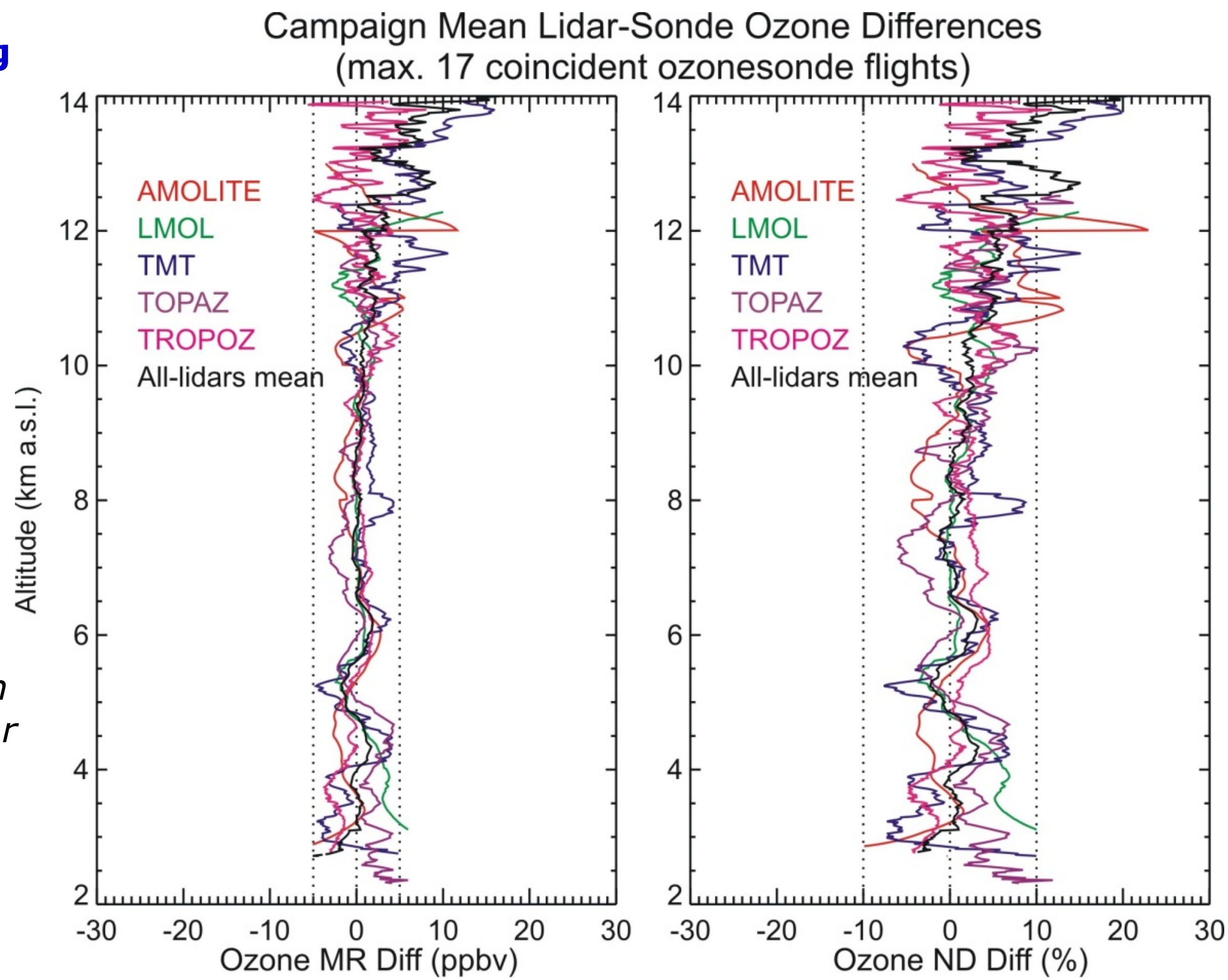
- *satellite validation*
- *long-term monitoring (trends)*
- *process studies (intrusions, air quality)*

Tropospheric Ozone DIAL Validation During SCOOP Campaign (August 2016)

4 visiting lidars during SCOOP campaign (TOLNet lidars)

All-lidar-mean bias with ozonesonde: +0.1 ppbv (0.6%) RMS: 0.9 ppbv (2%)

All differences are within the ozonesonde and lidar combined uncertainties



➔TOLNet lidars form a mature, robust ground-based reference network

(Leblanc et al., 2018)

Ozone Long Range Transport and Intrusions within tropopause folds

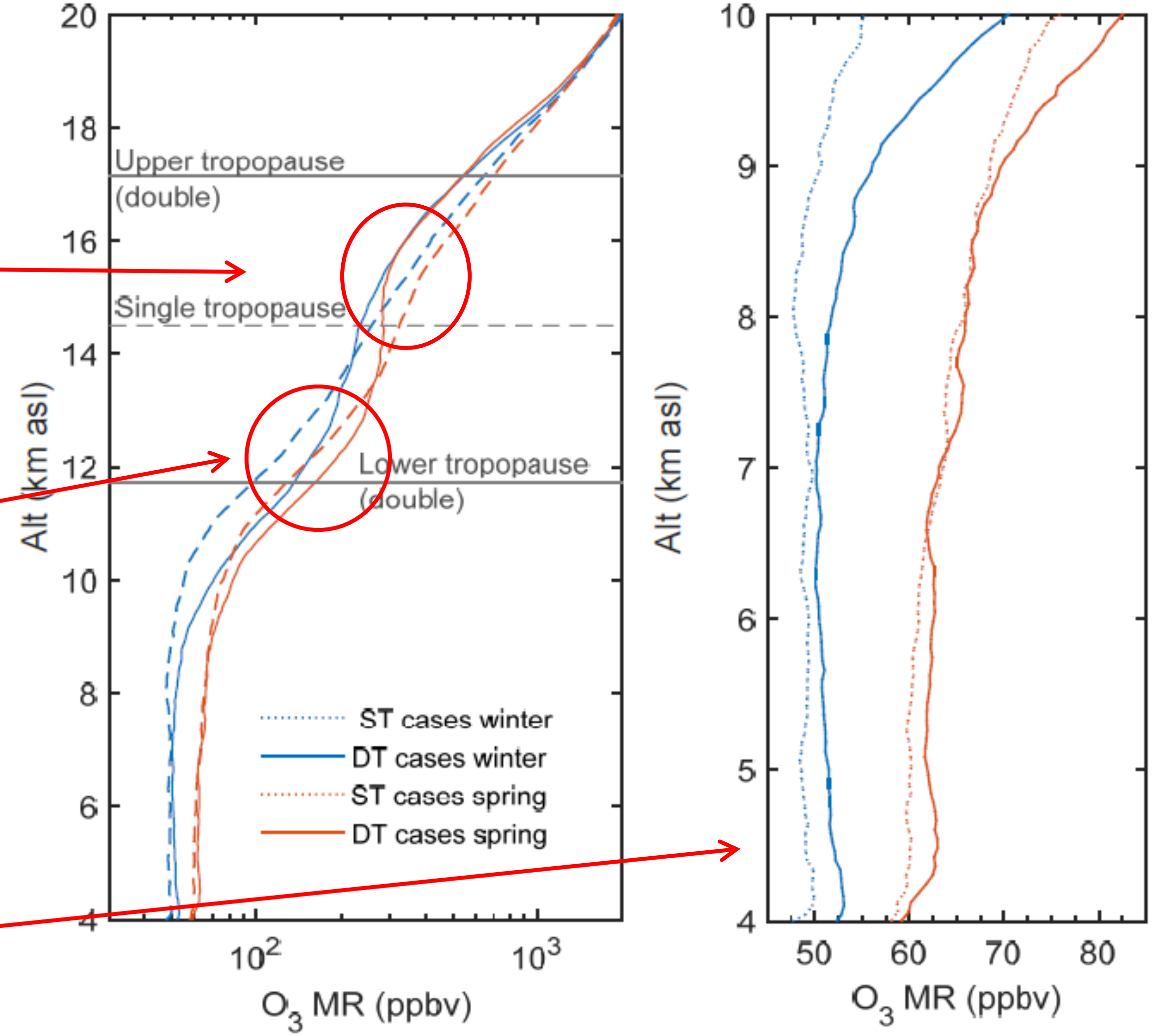
Distinguishing air parcels within tropopause folds

Dash curves: 15-year climato. without tropopause folds
Solid curves: 15-year climato. with tropopause folds

Low ozone in upper half of the fold (upper tropical tropo.)

High ozone in lower half of the fold ("middleworld")

Ozone anomalies extend well below tropopause folds!



(Granados-Munoz and Leblanc, 2016)

Typical NDACC Rayleigh Temperature Lidar

Emitter:
- *1 tripled Nd:YAG laser: 355 nm, 5 W, 50 Hz rep. rate*
- *Mirrors, beam expanders, motion controller for beam alignment*

Receiver:
- *1 large telescope (91 cm diam.) for high-intensity Rayleigh (25-90 km) and Raman channels (10-50 km)*
- *1 small telescope (10 cm diam.) for low-intensity Rayleigh channel (10-50 km)*
- *Mechanical chopper, dichroic beam splitters and interference filters for spectral separation*
- *Fast transient recorders for high sampling rate (e.g., 40 ns for 15 m sampling resolution)*

Strengths:
- *Mature technique (40+ years)*
- *Simple and inexpensive*

Caveats:
- *Assumes particle-free atmosphere (not always true in lower stratosphere)*
- *Requires "a priori" temperature knowledge at the top of the profile*
- *Daytime measurements not possible with standard equipment*

Applications:
- *satellite validation*
- *long-term monitoring and process studies (stratospheric warming, GW, tides, etc.)*

Two Examples of Rayleigh/Raman Temperature Profiles

Larger uncertainty at the top, due to:

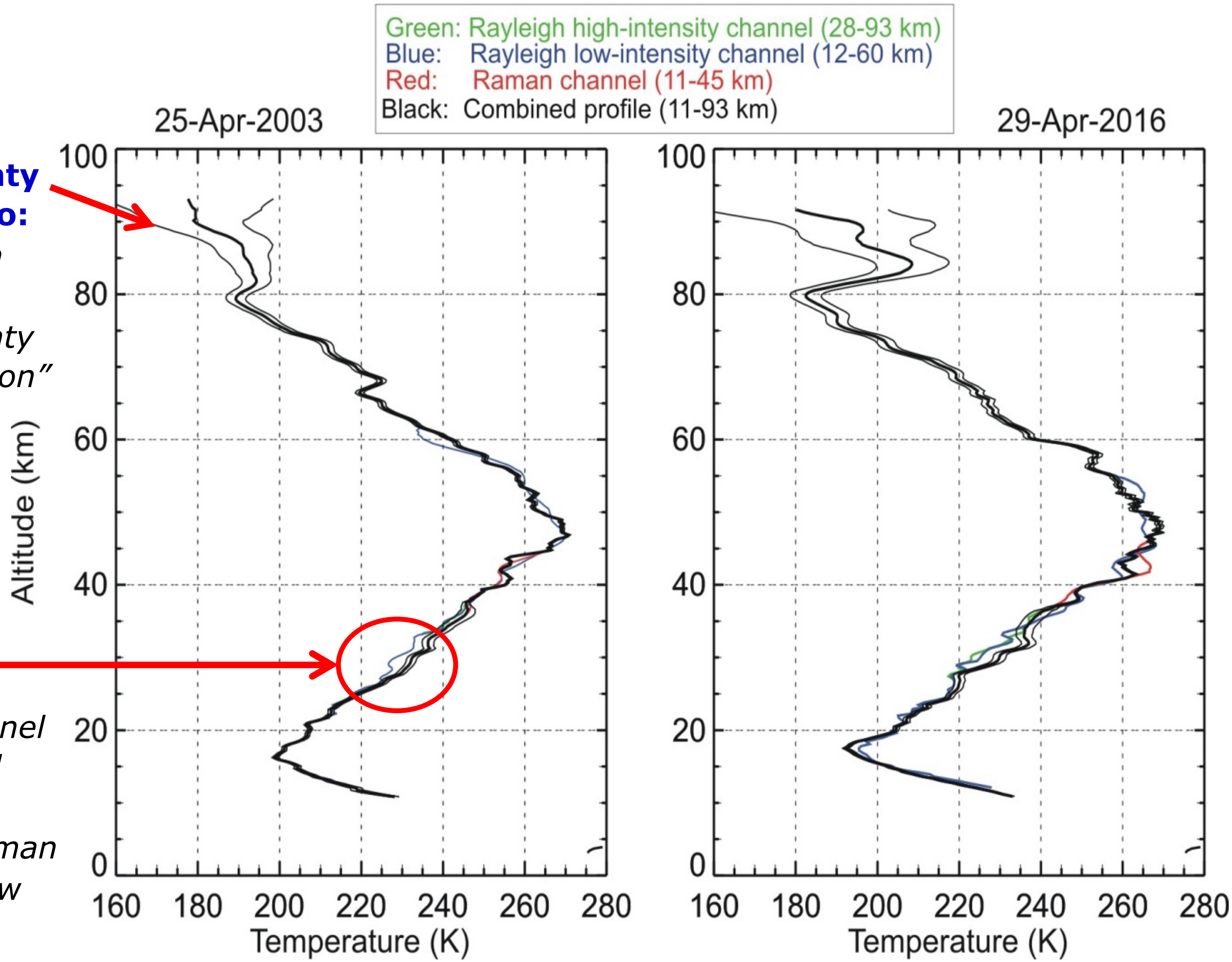
1) Lower precision (STNR)

2) Large uncertainty on a priori "tie-on" temperature

Impact of aerosols:

- Rayleigh channel yields too cold temperatures

➔ Must use Raman channel below 30 km



Typical NDACC Water Vapor Raman Lidar

Emitter:
- 1 tripled Nd:YAG laser: 355 nm, 7 W, 10 Hz rep. rate
- Mirrors, beam expanders, motion controller for beam alignment

Receiver:
- 1 large telescope (91 cm diam.) for high-intensity channels (5-20 km)
- 2 small telescope (10 cm diam.) for low-intensity channels (3-10 km)
- Dichroic beam splitters and interference filters for spectral separation
- Light collected at 387 nm (Raman N_2) and 407.5 nm (Raman H_2O)
- Fast transient recorders for high sampling rate (20 ns for 7.5 m sampling resolution)

Strengths:
- Mature technique (30+ years)
- Simple and inexpensive

Caveats:
- Requires calibration, typically from either radiosonde or GPS precipitable water
- Loses sensitivity in the upper troposphere due to the low H_2O VMR (a few ppmv)

Applications:
- satellite validation
- long-term monitoring for altitudes >10 km
- process studies for altitudes <10 km (cold fronts, stratospheric intrusions)
- Also, in theory: Operational model assimilation for weather forecast

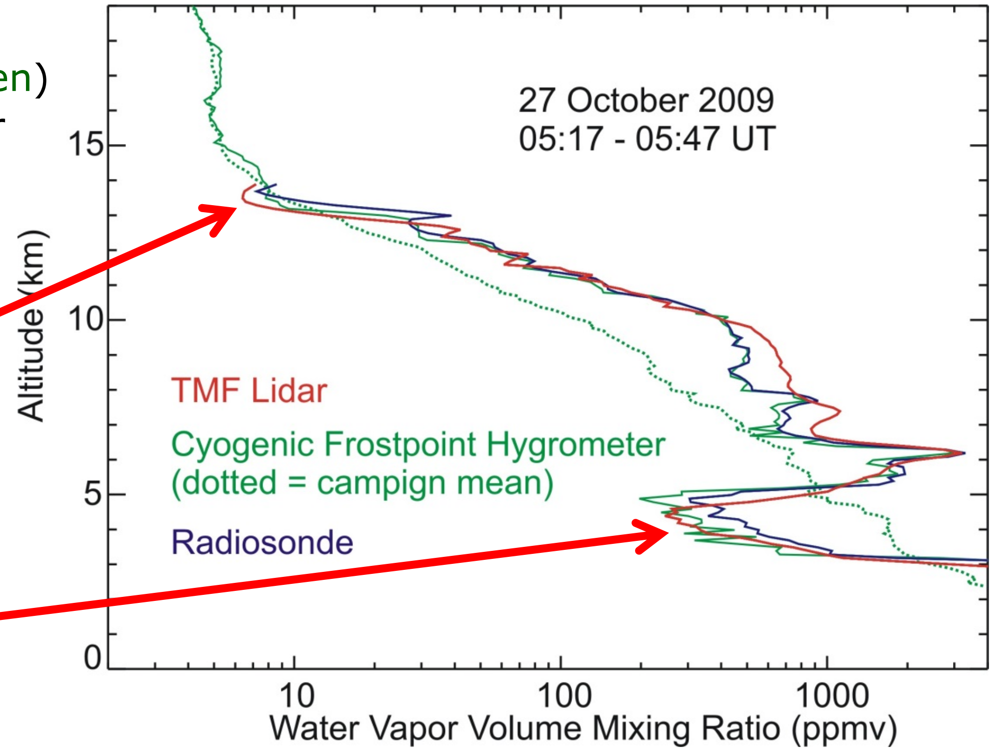
Example of H_2O Raman Lidar Profile

Cryogenic Frost-point Hygrometer (green) is research-grade reference hygrometer for upper air (10-30 km)

30-min lidar profile reaches 14 km i.e., same as radiosonde

Very high variability at small vertical and temporal scales (e.g., 4-6 km)

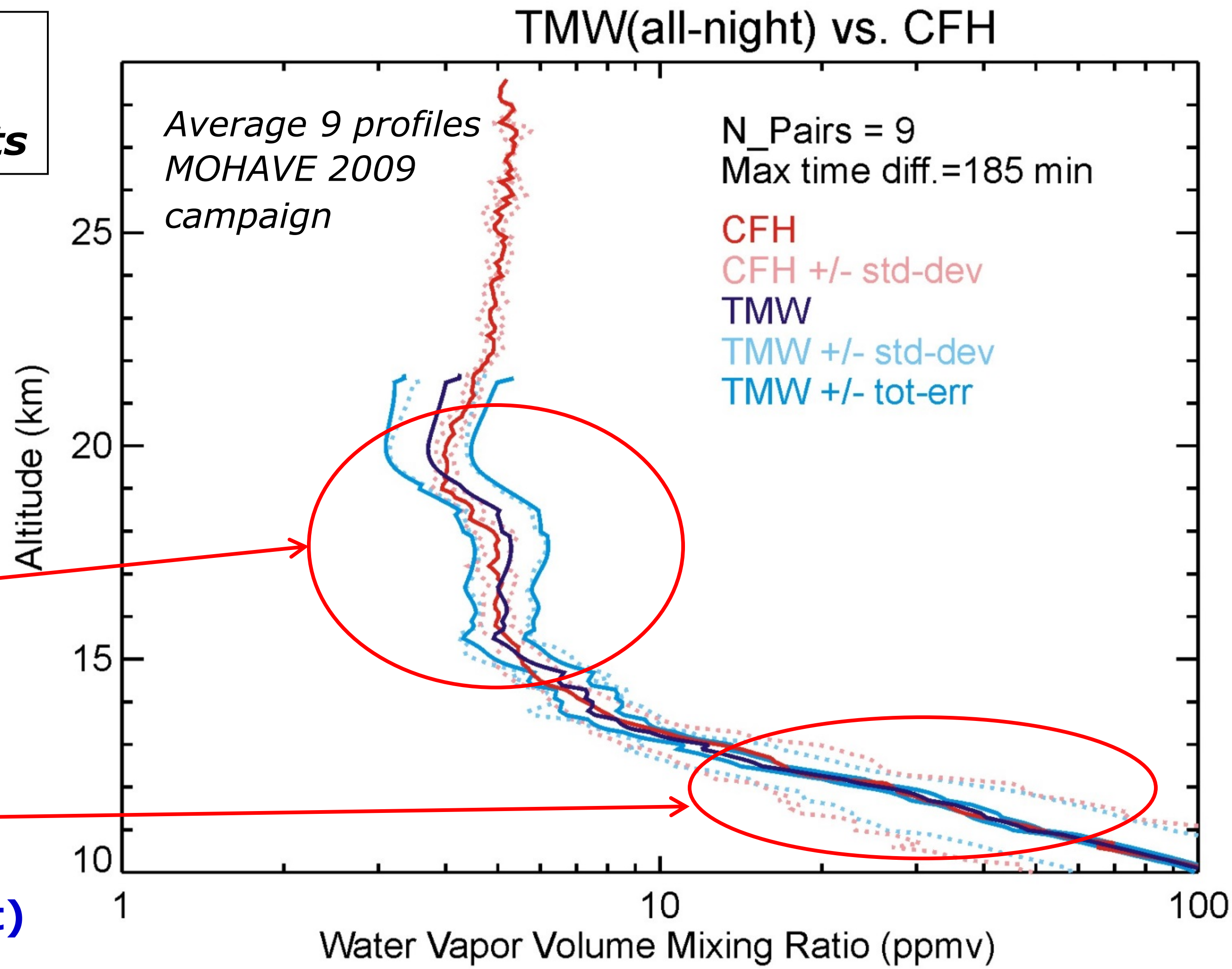
Lidar validation during MOHAVE 2009 Campaign



(Leblanc et al., 2011)

H_2O Raman Lidar for UTLS studies

TMF Raman lidar Optimized for UTLS measurements



Very challenging for H2O lidars to reach the LS

Good for UT (+/-5% diff. with Frost-Point)

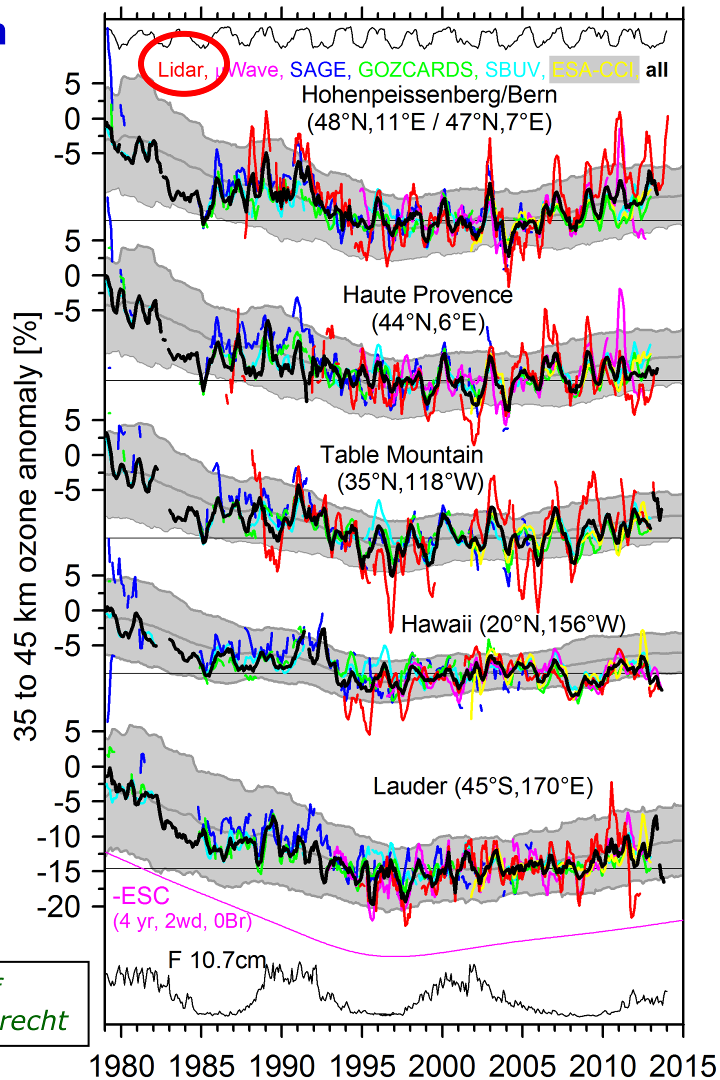
➔ Long integration times required for LS

(Leblanc et al., 2012)

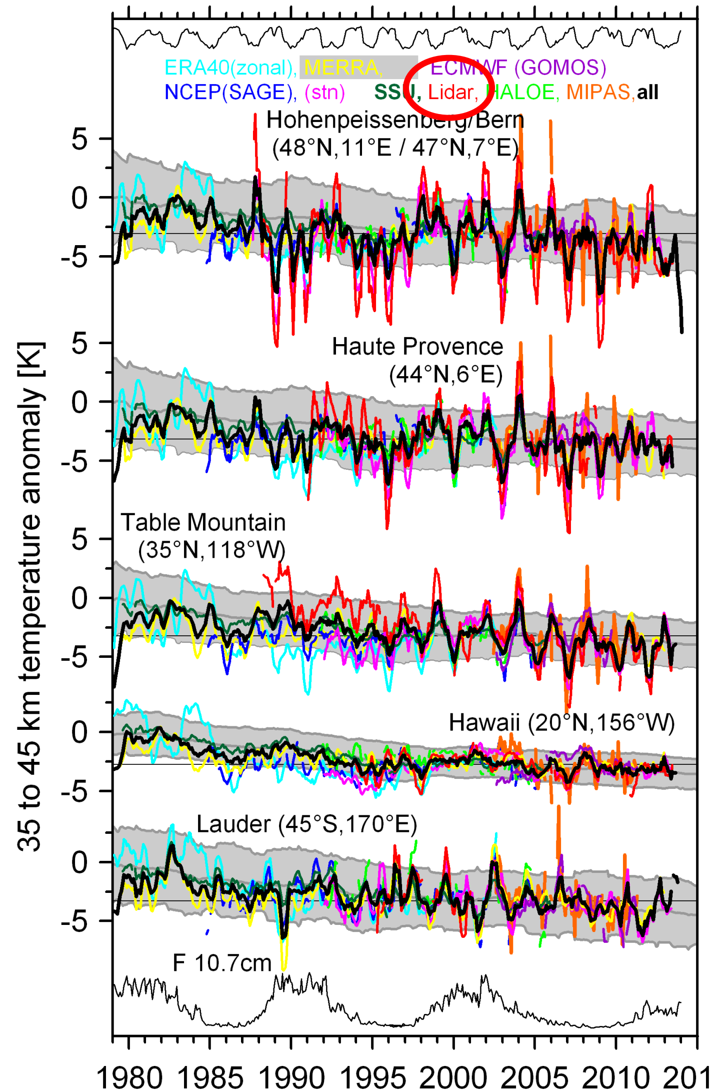
NDACC Lidars: Simultaneous Long-term Monitoring of Ozone and Temperature

Adapted from WMO Ozone Assessment Report

Stratospheric ozone



Temperature



Courtesy of Wolfgang Steinbrecht

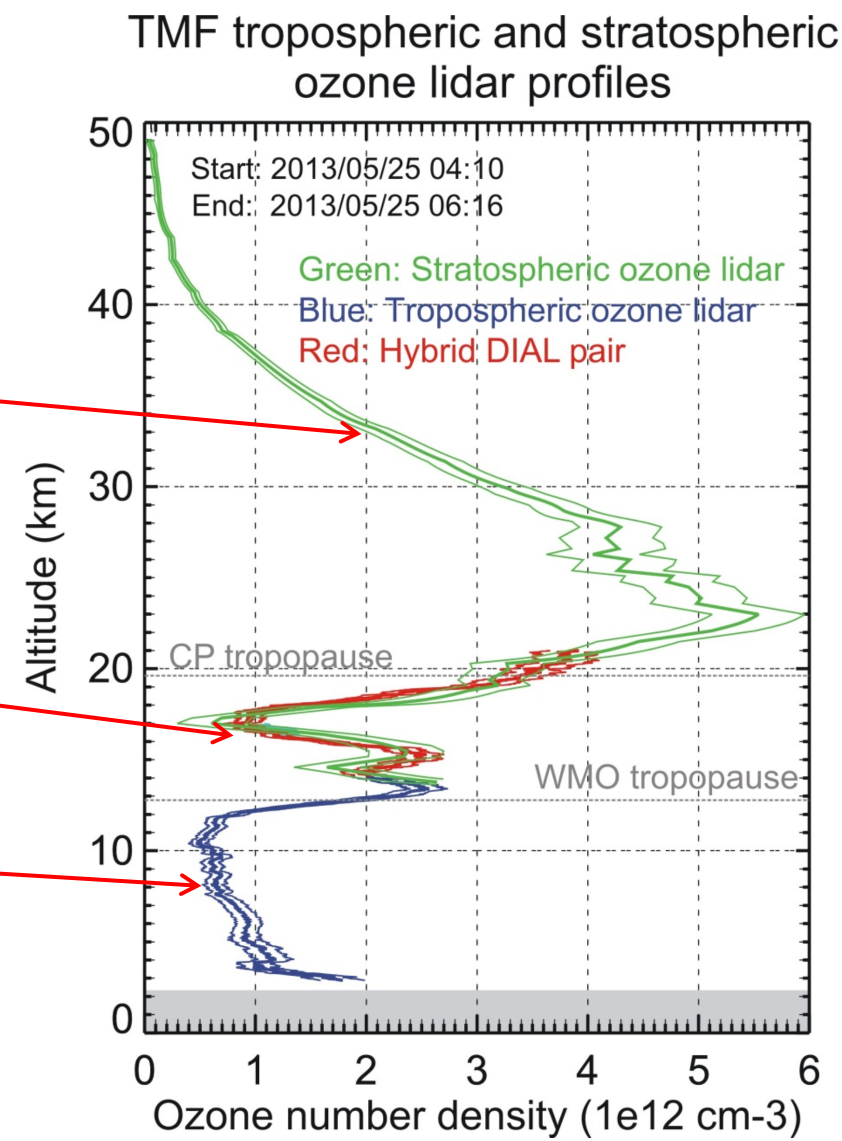
Synergy Between Multiple Co-located NDACC Lidar Instruments

Hybrid DIAL:
Use 1 channel of tropo O_3 DIAL and 1 channel of strato O_3 DIAL

Green (15-50 km): Strato. O_3 DIAL

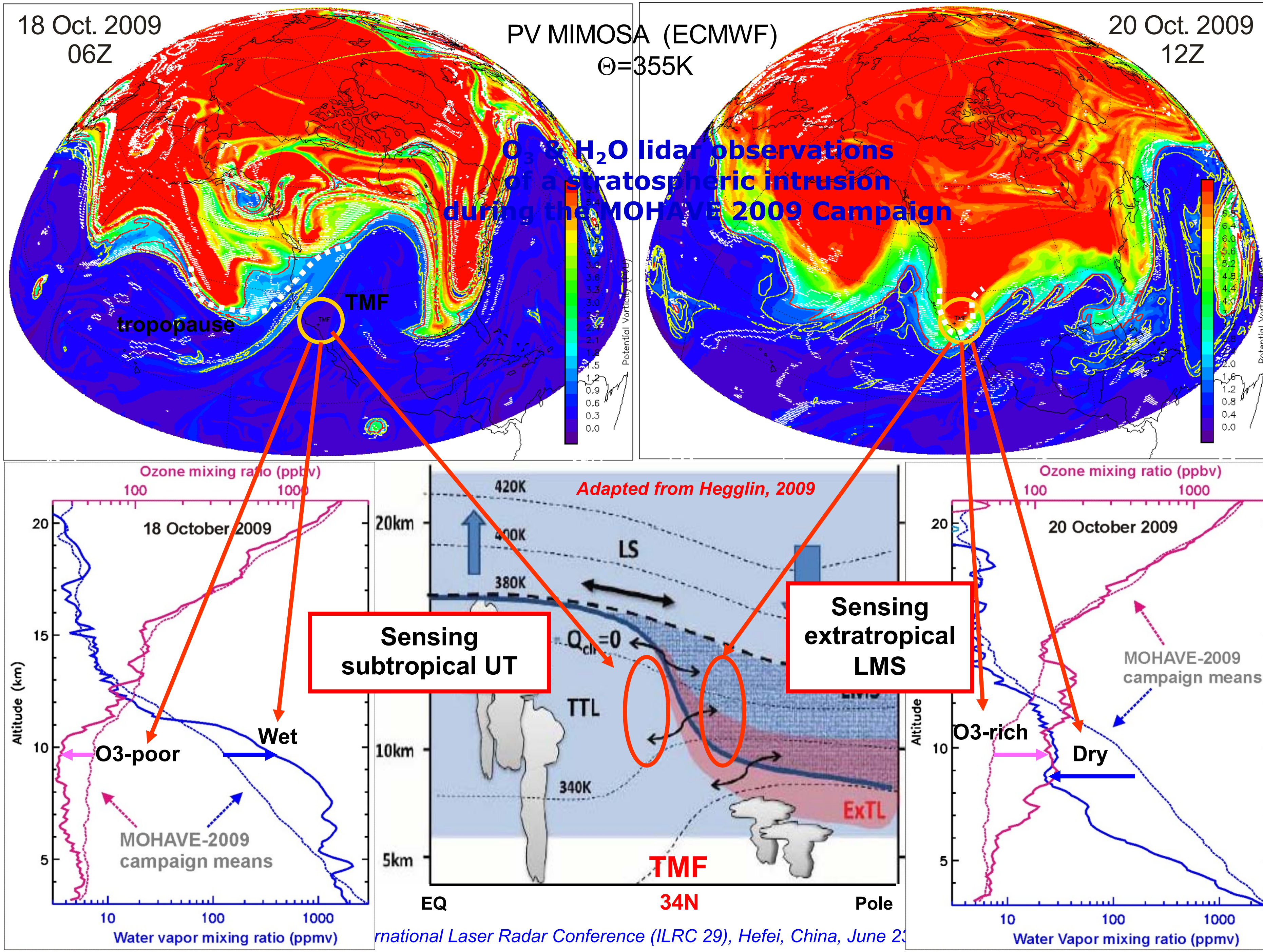
Red (15-22 km): "Hybrid" DIAL

Blue (3-15 km): Tropo. O_3 DIAL



(McDermid et al., 2012)

➔ Hybrid DIAL: excellent technique for the upper troposphere and lower stratosphere


O3 & H2O lidar observations
of a stratospheric intrusion
during the MOHAVE 2009 Campaign
18 Oct. 2009
06Z
PV MIMOSA (ECMWF)
Θ=355K
20 Oct. 2009
12Z
TMF
tropopause
Potential Vorticity (PVU)
Ozone mixing ratio (ppbv)
18 October 2009
Altitude (km)
O3-poor
Wet
MOHAVE-2009
campaign means
Water vapor mixing ratio (ppmv)
Adapted from Hegglin, 2009
420K
400K
380K
340K
LS
TTL
ExTL
20km
10km
5km
Sensing
subtropical UT
Sensing
extratropical
LMS
TMF
34N
EQ
Pole
20 October 2009
O3-rich
Dry
Water Vapor mixing ratio (ppmv)
rnational Laser Radar Conference (ILRC 29), Hefei, China, June 2

Significant Contributions of NDACC to International Research Initiatives and Assessments

WMO:
- Scientific Assessment of Ozone Depletion

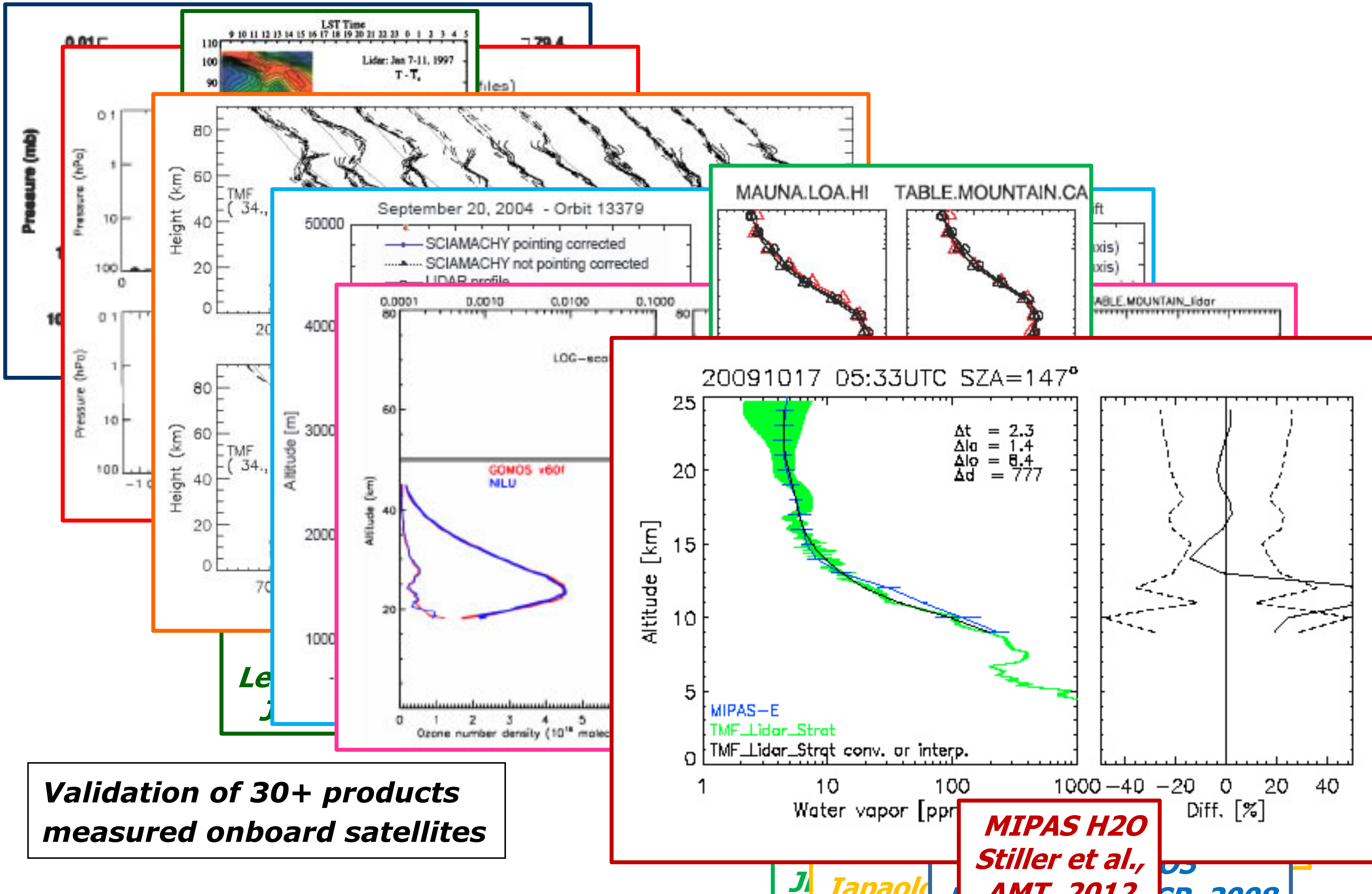
TOAR:
- *Tropospheric Ozone Assessment Report*
- *LIDAR, FTIR, O3 sondes*

SPARC:
- *CCl4 Trends*
- *SI^{2}N: Long-term Ozone and Temperature Trends Assessment for WMO*
- *LOTUS: Long-term Ozone Trends and Uncertainties in the Stratosphere*

NDACC is a reference network for the Copernicus Climate Change Service (C3S):
- *NDACC data will be turned into Climate Data Records (CDR) for delivery to the Climate Data Store - start with O3, CO, CH4*

"Ground-truth" Validation:
- *The Copernicus Atmospheric Monitoring Service (CAMS)*
- *The ESA Climate Change Inititative (CCI) programme – phase 2*
- *Satellite Validation: Recently TROPOMI, Aura, AQUA, CALIPSO, ENVISAT, NPP*

3 Decades of Satellite Validation



Validation of 30+ products measured onboard satellites

THANK YOU